

Optimisation and treatment of underwater bridges

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✓ The motivation for the choice of subject :

The primary goals of every underwater inspection project should be to complete the work safely and to provide a thorough and accurate inspection. Proper planning is essential to achieving these goals. Inspection teams must plan for safety; plan for conducting the inspection; plan for what is expected; and plan for what is unexpected

In addition, the most project motivated me to choice this subject is

Steep, icy mountains and deep fjords make western Norway famously scenic, but they also make life difficult for motorists. With seven ferries along the way, the almost 700-mile trip between the cities of Kristiansand in the south and Trondheim in the north typically runs about 21 hours — at an average speed of about 30 miles an hour.

However, that could soon change. A \$40-billion infrastructure project being planned by the Norwegian government aims to replace the ferries with bridges, conventional tunnels and what could be the world's first “floating tunnel.”

The submerged roadway — essentially a pair of concrete tubes submerged about 100 feet below the water's surface — would help cut the Kristiansand-Trondheim travel time almost in half while minimizing the environmental impact on the area.

❖ Introduction :

Oceans, rivers, and lakes are often beautiful, but they are not necessarily convenient places to build things. Yet, many types of the infrastructure we depend on every day, including wharves, bridges, and dams, are founded below the water. Whether the construction site is on the bottom of a lake or river, or simply located in the floodplain and only at risk during extreme weather, engineers and construction contractors put a significant amount of thought and consideration into the feasibility and costs of managing this water.

An **underwater bridge** is a military structure that was employed during World War II and the Korean War.

Underwater bridges, typically constructed of logs, sand and dirt just beneath the surface of the water in a river or similar narrow body of water, allow heavier vehicles to cross the river driving through only shallow water. Air reconnaissance finds such "bridges" difficult to spot; even if spotted, air strikes have difficulty in destroying them, as the water protects the structure from blasts.

The life of any bridge depends on the preservation of the physical integrity of both the superstructure and substructure; therefore, the implementation of an adequate inspection, maintenance, and repair program for the entire structure is essential. However, because there have been few catastrophic failures of bridges, there has been minimal interest in underwater inspection. Unfortunately, in many cases, the condition of the parts of the substructure located under water is not as easily determined as the condition of those parts located above water. The quality of inspection under water should be equal to the quality of inspection above water. Inspection of the underwater portions of structures is more difficult; the harsher environment affects the inspector's mobility, visibility, and such functions as cleaning and sampling. However, properly trained, equipped, and supervised personnel can do an effective job.

✓ **NEED FOR UNDERWATER INSPECTION :**

Because there have been few catastrophic failures of bridges, there has been minimal interest in underwater inspection. Some substructure components have never been inspected as inspection below the waterline is a difficult procedure. Although it is hoped that future

inspections will not identify any serious problems, aging structures, greater loads, and recent unusual weather all contribute to making underwater inspection an essential procedure today.

Yesterday's technology enabled the construction of underwater structures; today's technology permits inspection of these structures, correction of construction errors, and performance of maintenance and repair work. The bridge substructure is the structural element that serves as a link between the superstructure and the supporting material. The top of the substructure provides the bearing surface for the support of the superstructure, whereas the lower part or foundation transmits to the supporting soil all the loads and forces acting on the bridge, including those acting on the substructure itself. The ratio between the construction cost of the substructure and the cost of the superstructure varies according to the physical characteristics of the crossing and the type of bridge.

In general, the cost of the substructure is always a substantial percentage of the total construction cost of the facility, and, in many cases, this cost equals or closely approaches the cost of the superstructure. The life of any bridge depends on the preservation of the physical integrity of both the superstructure and the substructure; therefore, the implementation of an adequate inspection, maintenance, and repair program for the entire structure is essential. Unfortunately, in many cases, the condition of the parts of the substructure located out of sight, below the waterline, is

not as easily determined as the condition of those parts of the substructure located above the waterline and that of the superstructure.

✓ Maintenance intervention optimisation for existing railway bridges:

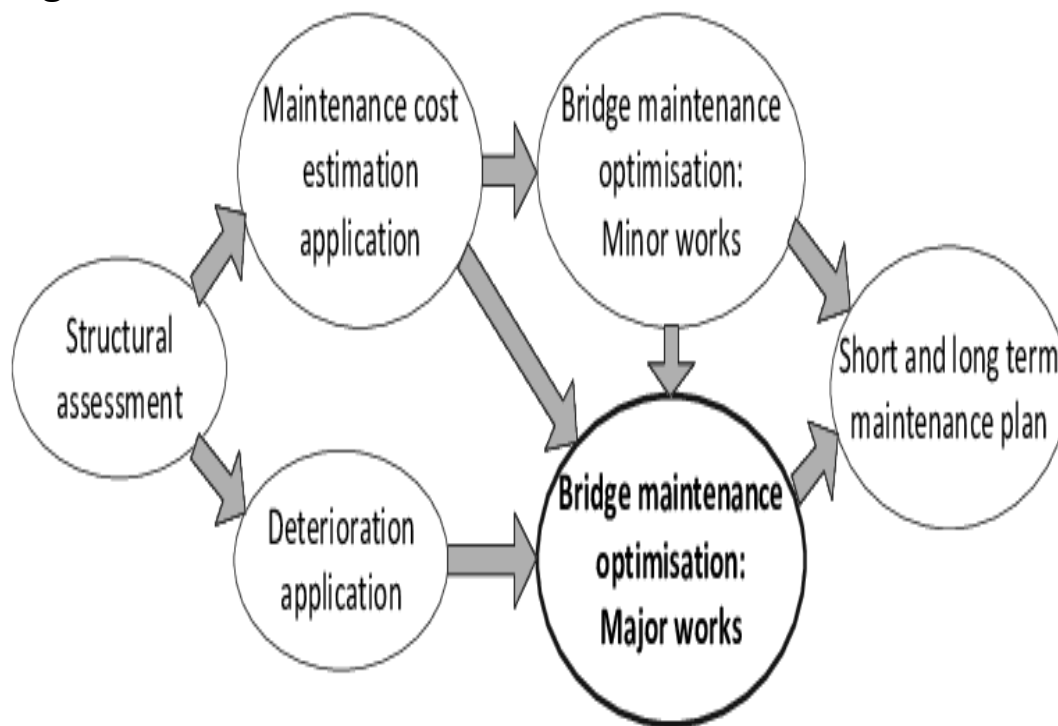
- ABSTRACT:

Maintenance of aging infrastructure is a burden on many organizational budgets, and Life Cycle Cost Analysis (LCCA) is accepted as an effective method to reduce these costs. However, LCCA becomes extremely complex when applied at the individual bridge component level within a large bridge population while considering multiple maintenance strategies, varying deterioration rates and intervention intervals. To address this concern, a decision support model is presented that proposes maintenance actions for future interventions based on a selection of maintenance strategies and given organizational budget constraints. The remaining service life of surrounding components is considered when assessing the most appropriate maintenance actions. Three popular bridge management strategies are considered in this model, comprising refurbishment, upgrade and renewal strategies. The infrastructure manager may apply one of these three strategies at the bridge

level to estimate future network budgets or align with existing budgets. The developed decision support application allows “what-if” scenarios to be generated to determine life cycle costs by changing life gained from maintenance actions, maintenance costs, maintenance strategy, discount rate, intervention trigger time and minimum intervention intervals.

Total maintenance costs over the lifespan of a structure may be higher than the structure’s initial construction cost. As some bridge structures can function well beyond 100 years life, the initial construction cost may seem small compared to current maintenance costs. Due to this reason, a discount rate is applied to future expenditure to show the changing value of money (Nielsen et al., 2013b). The discount factor can have a large effect on delaying expensive upgrade maintenance actions, causing the model to select lower cost maintenance actions.

Figure 1 - Bridge management application Framework



The refurbish maintenance strategy usually has the lowest short-term cost of the major maintenance strategies. It generally requires components to be replaced with the same or similar component, design and material. The expected life gain from the new component is similar to the life gained from the replaced component and interventions may be required frequently. Consequently, this strategy may have a relatively higher cumulative maintenance cost over the life of the structure when compared to other strategies. The objective of this strategy is to maintain a safe structure at the lowest immediate cost with a disregard to possible higher future maintenance costs. Accordingly, this strategy does not use LCCA and is commonly employed by rail organizations with low maintenance budgets. The purpose of this strategy is to plan maintenance on short life railway lines or lines that are expected to close within a short time period. Another

purpose of this strategy is to allow a comparison of costs between strategies. The second strategy, called the upgrade strategy, typically has a higher upfront cost than the refurbish strategy and aims to replace deteriorated components with longer life components. This may include upgrading a timber bridge deck to a steel or concrete deck. The objective of the upgrade strategy is to maximize the life of existing structures through refurbishment and upgrading maintenance actions to give the longest structural life at the lowest life cycle cost. The objective function for optimization of the upgrade strategy is given in Equation 1. The application of this strategy initially minimizes cumulative maintenance costs over three maintenance interventions and reduces the average condition of components with lower cost maintenance actions before commencing an upgrade of the structure. Every combination of refurbishment and upgrade maintenance activity is evaluated in the application until the greatest cost benefit over three intervention periods can be realized.

Minimise (life cycle maintenance costs/ life gained by maintenance)

Figure 2: effect of maintenance on component life

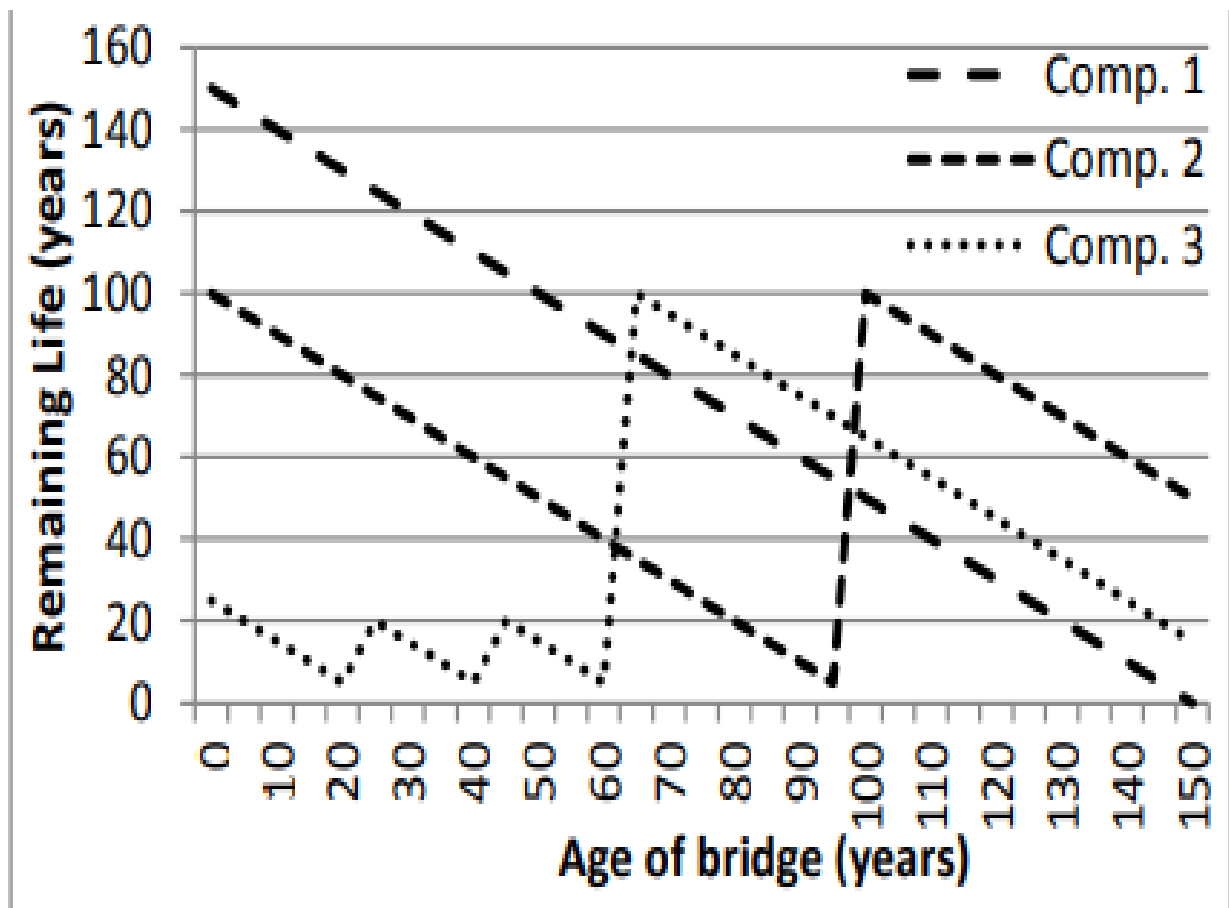
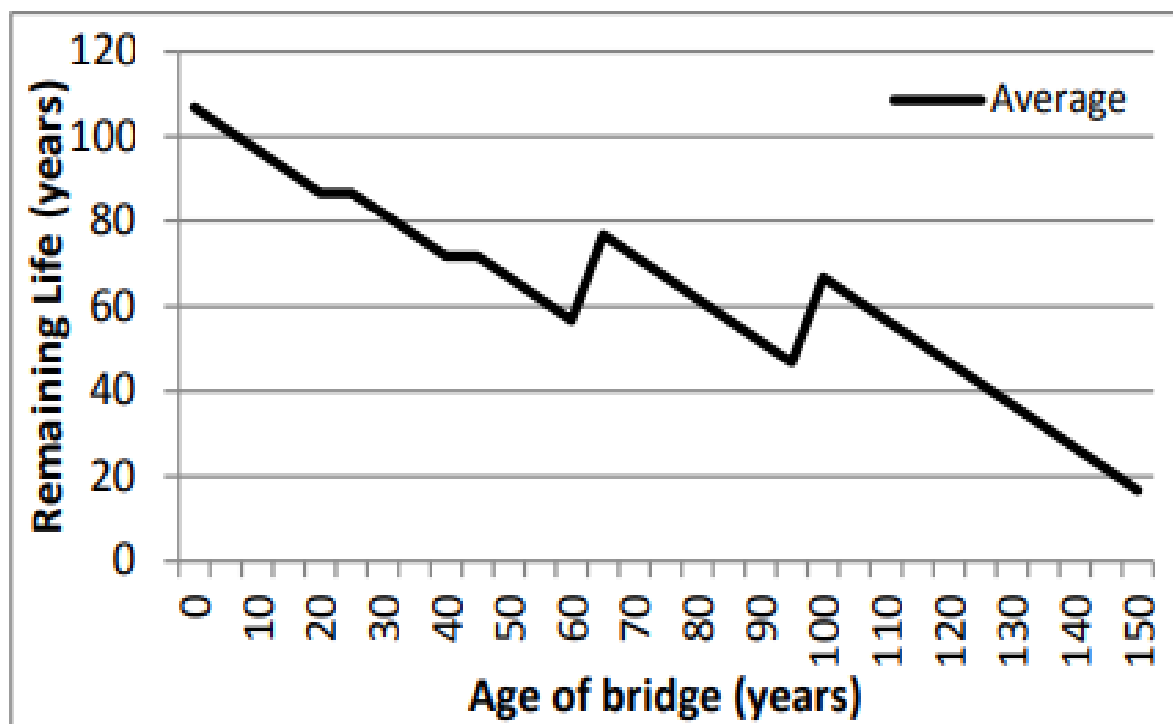


Figure 3 : Average remaining life of all bridge components



Applications in Morocco:

RABAT--The British government led by Boris Johnson is studying the completion of an undersea tunnel linking Gibraltar to Tangiers, in partnership with the Moroccan government.

Therefore, it is possible to see this kind of projects in morocco like the strait of Gibraltar

Strait of Gibraltar crossing :

the **Strait of Gibraltar crossing** is a hypothetical bridge or tunnel spanning the Strait of Gibraltar (about 14 km or 9 miles at its narrowest point) that would connect Europe and Africa. The governments of Spain and Morocco appointed a joint committee to investigate the feasibility of linking the two continents in 1979, which resulted in the much broader Euro med Transport project.

In January 2021, it was reported that the United Kingdom and Morocco would discuss building the crossing between Gibraltar and Tangiers.

Tunnel:

Various tunnels have been proposed Spain first proposed a modern tunnel under the Strait of Gibraltar in 1930.

A major problem arose when the engineers hired by the Spanish government discovered that the

material under the Strait was extremely hard rock, making tunneling impossible with the available technology. One engineering solution was to fix, using cables, and a prefabricated concrete tunnel to the floor of the Strait. This tunnel would handle automotive and train traffic.

A 2008 geological study cast doubt on the tunnel's feasibility. In March 2009, a contract was issued for a joint system linking the Moroccan *Société Nationale d'Etudes du Détroit de Gibraltar* (SNED) with its Spanish counterpart, *Sociedad española de estudios para la comunicación fija a través del Estrecho de Gibraltar SA* (SECEGSA). A three-year study for a railway tunnel was announced in 2003. SNED and SECEGSA commissioned several seabed surveys.

The Strait depth extends to 900 metres (3,000 ft) on the shortest route, although it is only about 300 metres deep slightly further west, in a region known as the Camarinal Sill; the European and African tectonic plates meet around this area. The shortest crossing is 14 kilometers (8.7 mi). The proposed route of 23 kilometers (14 mi) is west of Tarifa and to the east of Tangier. The tunnel is likely to be about 34 kilometres (21 miles) in all. It is proposed that a connection would have to be made to the Spanish high speed railway network, which has a line projected to be built from Cádiz to Málaga via Algeciras.

A report on the feasibility of the tunnel was presented to the EU in 2009. A further project study is under development by a group of specialist consultants from SYSTRA, Amberg and COWI

✓ Planning

In December 2003, Spain and Morocco agreed to explore the construction of an underwater rail tunnel to connect their rail systems. The tunnel would have linked Cape Malabata near Tangier with Punta Paloma in the El Estrecho Natural Park 40 kilometres (25 mi) west of Gibraltar. In late 2006, Lombardi Engineering Ltd, a Swiss engineering and design company, was retained to draft a design for a railway tunnel.[[] According to the company, the main differences between the construction of this tunnel and that of the Channe Tunnel, linking France and Great Britain, are the depth of the sea and the geological conditions. The area under the Strait is less stable than that under the English Channel. An active major geologic fault, the Azores–Gibraltar Transform Fault, bisects the Strait, and severe earthquakes have occurred in the area.

➤ Technical aspect :

The proposed rail tunnel's length is 40 kilometres , 300 metres deep, and its construction would take 15 years. An earlier plan was to link the two continents via the narrowest part of the strait, but this idea was dismissed as the tunnel would be 900 metres below sea level. For comparison, the currently deepest undersea tunnel, the

Norwegian Ryfylke Tunnel, is 291 metres below sea level. A tunnel deeper than Ryfylke is under construction, also in Norway, Rogfast will be 27 kilometres long and 392 metres deep, expected to be completed in 2028–29.



● References :

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[\(86\) Inside Norway's \\$47 Billion Floating Highway - YouTube](#)